

M E M O R A N D U M

TO: SIP Inventory Preparers and EPA Regions

FROM: Inventory Guidance and Evaluation Section
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SUBJECT: **VOC Emissions from Bakeries**

This technical memorandum was prepared by Radian Corporation under contract to the Office of Air Quality Planning and Standards, US Environmental Protection Agency (EPA Contract No. 68-D0-0125). The objective of this work assignment is to provide technical consulting to state and local agencies preparing 1990 base year State Implementation Plans (SIP) emission inventories. The interim procedures outlined in this memorandum may not conform to future releases of EPA procedures and guidance. However, they are based on the best data available at this time.

Several states have requested additional guidance in calculating emissions from bakeries. This memorandum discusses the recommended method for calculating emissions from bakeries and provides information that may be used to identify bakeries that should be classified as point sources, and describes the development of a per capita bakery emission factor.

Introduction

In "Procedures for the Preparation of Emission Inventories for Carbon Monoxide and Precursors of Ozone, Volume I: General Guidance for Stationary Sources", (Prepared by Alliance Technologies Corporation for EPA OAQPS/OAR, EPA-450/4-91-016), section 4.4.1, inventory preparers are advised to use AP-42 emission factors or American Institute of Baking (AIB) methods to determine bakeries as an area source. Both methods require an estimate of bread production. The procedures document recognizes the difficulty of such an estimate, and states that sales data can be used to estimate bread production. An issue of "Bakery Production and Marketing Magazine" from 1990 is recommended as a resource for national per capita sales data.

Estimating Emissions From Sales Data

Per capita sales data can be transformed into a per capita emission factor fairly easily. As an example, we will use 1987 sales data from "The U.S. Milling and Baking Industries" (Harwood, J.L., Leath, M.N., and Heid, W.G., 1989, U.S. Dept. of Agriculture, Agricultural Economic Report No. 611). Other sources, such as the 1990 "Bakery Production and Marketing Magazine" retail trends issue can be used. The more recent sources are recommended. A difference of 10 lbs in annual per capita consumption will result in a 0.05 lb difference in per capita emissions, a 2 lb change in annual consumption results in a .01 lb per capita emission change. Per capita consumption for yeast breads for the years 1982 through 1987 ranged from a low of 61.78 lbs in 1987 to a high of 63.68 lbs in 1984, a difference of 1.9 lbs. As an example, Table 1 presents the consumption data for all baked goods, including non-yeast baked goods, from 1987. This is typical of the type of information available in the literature.

Table 1.

Per Capita Consumption of Bread and Related Products *	
Product	Pounds per Person
All Breads	45.22
White Pan	26.48
Unspecified	1.96
Variety Types	16.78
Rolls	13.02
Hamburger and Hot Dog	10.81
Brown and Serve	1.11
Hearth	1.10
Sweet Yeast Goods	3.54
Doughnuts	.58
All Other	2.96
Soft Cakes	5.28
Snack Cakes	3.88

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Per Capita Consumption of Bread and Related Products *	
Product	Pounds per Person
All Other	1.40
Pies	1.94
Snack Pies	1.11
All Other	.83

Per Capita Consumption of Bread and Related Products *	
Product	Pounds per Person
Cake-Type Doughnuts	1.75
Total	70.75
* Estimated by the U.S. Dept. of Commerce, International Trade Administration	

In this example, consumption figures for a number of different baked goods are listed. Since the overwhelming amount of emissions from bakeries are those from yeast fermentation, products that do not use yeast do not need to be included in the inventory. The yeast products in this list are: all breads, rolls, and sweet yeast goods. Consumption figures for those categories can be summed to get the total annual consumption of these products per person (61.78 lbs/yr). Using a sum of all baked goods (70.8 lbs/yr in 1987) will result in a higher emission factor.

The AP-42 emission factors for yeast bread emissions are presented in Table 2.

Table 2.

Bakery Emission Factors	
Process	Emission Factor (ethanol/lbs. bread)
Straight-Dough	0.5 lb/1,000 lb
Sponge-Dough	5 to 8 lb/1,000 lb

VOC's from bakeries are primarily ethanol which result from yeast fermentation. Bakery products that are not leavened with yeast do not produce ethanol and should not be considered for the VOC inventory. The emission factors that follow represent emissions of ethanol from either the straight-dough or sponge-dough yeast leavening processes. Straight-dough leavening, (which is used less frequently by commercial bakers), is when ingredients are mixed, the yeast is allowed to ferment, and then the bread is baked. The sponge-dough process uses a larger amount of yeast to start the bread, but a smaller portion of the other ingredients,

with the rest of the ingredients being added before baking. Most of the emissions (99%) from sponge-dough leavening take place during baking. The straight-dough process has much lower emissions, emitting 77% during baking, 23% during other steps, and retaining a much higher concentration of ethanol in the baked bread (2,000 ppm vs 1 ppm) ("Preliminary Review of 19 Source Categories of VOC Emissions", 1988 Draft Report by Radian Corporation for EPA OAQPS/ESD).

Since commercial bakeries are most likely to use the sponge dough method, and the sponge dough emission factor is higher and thus more conservative, the lower sponge dough emission factor is used to compute the example per capita emission factor.

$$\begin{aligned} 1,000 \text{ lb} / (61.78 \text{ lb /capita}) &= 16.2 \\ 5 \text{ lb} / 16.2 &= 0.31 \text{ lb VOC / capita} \\ \text{or, } &.155 \text{ tpy VOC / 1,000 people.} \end{aligned}$$

Bakeries as Point Sources

Although many bakeries are fairly small and their emissions can be part of the area source inventory, some of the larger bakeries are point sources for VOC. Using 1982 data derived from three tables in "The U.S. Milling and Baking Industries" (Harwood, J.L., Leath, M.N., and Heid, W.G., 1989, U.S. Dept. Of Agriculture, Agricultural Economic Report No. 611), approximate emission rates for bakeries by the number of employees has been calculated, and are in Table 3. The 1987 Census of Manufactures, which is published on a state by state basis, should contain the county level employment data necessary to do this screening procedure. Large bakeries will be listed under the Standard Industrial Classification (SIC) number 2051. Retail bakeries, which should be fairly small, will be listed in the Census of Retail Trade, and will be under the retail SIC number of 546.

Table 3.

Emission Estimates by Employees		
Plant Size by Employees	Average Pounds of Bread per Plant per Year	Average Annual VOC Emissions per Plant (tons)
1 - 19	236,995	.59
20 - 49	1,469,986	3.67

50 - 99	4,424,889	11.06
> 100	21,364,217	53.41

This emission estimate has been calculated using individual consumption, individual sales, average plant shipment value and the sponge dough emission factor of 5 lbs VOC/1,000 lbs bread. Shipment values for plants in the Dept. of Agriculture document did not distinguish between the values of yeast bread products and other baked goods, and proportions had to be taken based on the proportions between these types of products listed for individual consumption and individual sales. Plant emission estimates, based on actual production may be higher or lower if the plant's products are all breads or all cookies.

The values in Table 3 should not be used as a substitute for site-specific data and calculation. They are provided for use as a screening tool. Based on the table, any facilities with 50 or more employees should be treated as a point source.

These emission estimates are based on 1982 data because the source document did not have appropriate data for later years. Since that time, based on information in the same document, very large bakeries have increased their market share at the expense of smaller bakeries, and those larger bakeries are newer, more automated, and more efficient. Thus, the trend is toward higher production relative to the number of employees.

Inventory preparers have several tools available for estimating VOC emissions from bakeries: the per capita emission factor and the employee screening method presented in this memo, and a survey for point sources as presented in the procedures document. A possible series of actions for completing this inventory might be:

1. Use the most recent census data available and the employee screening table to identify possible point source bakeries (those with more than 50 employees) within the non-attainment area.
 - a. If there are no bakeries that have more than 50 employees, use the per capita method to calculate an area source emission estimate.

- b. If there are bakeries with > 50 employees, then complete steps 2 and 3.
2. Survey those bakeries that have more than 50 employees as point sources. Use AP-42 guidance to determine the data needs; the survey should also include pounds of yeast-risen baked goods produced and number of employees. Use AP-42 methods to determine emissions from those point sources.
3. Area source emissions must now be calculated. Inventory preparers have two options:
 - (a) Use the point source data that has been collected to calculate a local VOC / employee emission factor. The procedures manual has guidance for scaling up the inventory from point source information in section 5.6.
 - (b) Use a per employee emission factor derived from 1980's national data. Information used to create the emission estimates for the three lower employment ranges in Table 3 of this memo have been weighted and averaged, resulting in an emission factor of .11 tons VOC / employee. Multiply this factor times the employees not counted in the point source surveys. Remember to include employees listed under the SIC codes for manufacturers and retail bakeries.

As for all categories, document all choices and calculations used for these emission estimates.